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Conservation of Grassland Plant Genetic Resources through People Participation

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ABSTRACT

Agrobiodiversity provides the foundation of all food and feed production. Hence, need of the time is to collect, evaluate and utilize the biodiversity globally available. Indian sub-continent is one of the world's mega centers of crop origins. India possesses 166 species of agri-horticultural crops and 324 species of wild relatives. India is reported to have five grass covers identified. There have been almost nil human interference in terms of selection pressure; hence, the biodiversity is well conserved in these grazing lands. There is need of a system approach to understanding biodiversity that moves significantly beyond taxonomy and species observations. In addition to forage value, many grasses hold the medicinal value. Duplication in the collected germplasm is a serious issue. Hence, molecular tools need to be employed. Indian Grassland and Fodder Research Institute, Jhansi is maintaining >8500 germplasm of many fodder crops. For thousands of years farmers have been domesticating plant species thereby developing a wide range of crop varieties adapted to specific needs and environmental conditions and their rights have been protected through Indian Plant Variety Protection and Farmer's Right Act. The use of diverse species and varieties by farmers enhances their adaptability and resilience capacity to changing environmental and economic conditions. **Farmers in Manipur are conserving the biodiversity of the state by farming around 100 traditional varieties of paddy and rare medicinal plants.** Old grasslands are very good place of conservation. Southern India forms the important genetic resource centre for many grass crops which includes cereals, millets, sugarcane, lemon grass, ginger grass etc. farmers in Maharastra are also conserving PGR and maintaining Biodiversity Register of the grassland species under guidance of *Samvedana*. "Community based conservation" and "peoples' participation" have become part of the conventional rhetoric. Wealth of segregating breeding population also need to be conserved. The grasses or other species in grasslands are growing in highly diverse and harsh condition. These are harbouring genes for tolerance to many abiotic stresses such as light, heat and salinity/alkalinity. Hence, this wide variability, if conserved suitably, can prove to be resource to address climate change issue.

Keywords: Conservation, Participatory, Plant genetic resource,

Introduction

With only 2% of the World's geographical area, India supports 20% of the world's livestock. It holds 16% cattle and 55% of world buffalo population and has the world's second largest goat (20%) and fourth largest sheep (5%) population. The available forages are poor in quality, being deficient in available energy, protein and minerals. The share of forages in cultivated land remains <5% in the country for many years. The fodder resource from grasslands is also quite less due to denuded grazing lands owing to heavy grazing pressure. Biodiversity refers to the multiplicity of life forms that exist on the planet. Agrobiodiversity is an evolutionary divergent line of biodiversity concerned with agro-ecosystems and variation in agriculture related plants, animals, fish, insects and other flora and fauna in agro ecosystems as well as elements of natural habitats that are part of food production cycle. Agrobiodiversity provides the foundation of all food production. Hence, need of the time is to collect, evaluate and utilize the biodiversity globally available for welfare of mankind. In the present article focus will be more in Indian context.

Indian Grassland Biodiversity

Indian sub-continent is one of the world's mega centers of crop origins and plant diversity as it represents a wide spectrum of eco-climate. Genetic diversity comprising native species and land-races occurs more in Western Ghats, Deccan Plateau, Central India, North Western Himalayas and North Eastern Hills. India has 141 endemic genera belonging to 47 families of higher plants. Of the 4200 endemic species, Himalaya accounts for 2532 species, followed by peninsular region (1788 species) and Andaman and Nicobar islands (185 species). India possess 166 species of agri-horticultural crops and 324 species of wild relatives. It also possesses rich genetic diversity with regard to native grasses and legumes. There are reports of 245 genera and 1256 species of Gramineae, of which about 21 genera and 139 species are endemic. One third of Indian grasses are considered to have fodder value. Most of the grasses belong to the tribes Andropogoneae (30 %), Paniceae (15 %), and Eragrosteae (9 %). Similarly, out of about 400 species of 60 genera of Leguminosae, 21 genera are reported to be useful as forage. Some of the genera exhibiting wide forage biodiversity includes legumes like *Desmodium, Lablab, Stylosanthes, Vigna, Macroptelium, Centrosema* and grasses like *Bothriochloa, Dichanthium, Cynodon, Panicum, Pennisetum, Cenchrus, Lasiurus.*

Indian sub-continent represents a wide spectrum of eco-climate ranging from humid tropical to semi-arid, temperate to alpine. 550 tribal communities of 227 ethnic groups are spread over 5000 forested villages. Agro- bio-diversity in India is distributed in eight very diverse phytogeographical and 15 agroecological regions. These areas possess unique gene pools comprising land races, primitive forms and wild relatives.

Based on reconnaissance survey, India is reported to have five grass covers identified *i.e. Sehima – Dichanthium* type, *Dichanthium-Cenchrus-Lasiurus* type, *Phragmites-Saccharum-Imperata* type, *Themeda-Arundinella* type, and Temperate Alpine type. These naturally maintained grasslands are beautiful example of conserving large number of genera represented by various species and genotypes. In fact, there have been almost nil human interference in terms of selection pressure, hence, the biodiversity is well conserved in these grazing lands.

The *Sehima-Dichanthium* grass cover, lying approx between 8^{o} and 28^{o}N and 68^{o} and 87^{o} E, is represented by perennial grasses viz. *Dichanthium annulatum, Sehima nervosum, Bothriochloa pertusa, Chrysopogon fulvus, Heteropogon contortus, Iseilema laxum, Themeda triandra, Cynodon dactylon, Aristida setacea, Cymbopogon, Apluda mutica, Bothriochloa intermedia, Arundinella nepalensis, Desmostachya bipinnata, Eragrostis* and *Eragrostiella* spp. *Dichanthium-Cenchrus-Lasiurus* grass cover, between 23^{o} and 32^{o} N and 68^{o} and 80^{o}E, is mingled with grass species such as *Cenchrus ciliaris, C. setigerus, D. annulatum, Cymbopogon jawarancusa, Cynodon dactylon, Eleusine compressa, Laesiurus sindicus Sporobolus marginatus, Dactyloctenium sindicum, Desmostachya bipinnata* etc. Important associate species are: *Chloris, Desmostachya, Heteropogon* *contortus, Saccharum bengalense, Vitevaria zyzanioides*, etc. *Phragmites-Saccharum-Imperata* grass cover, between 26° and 32°N and 74° to 96°E, represents perennial species *Imperata cylindrica, Saccharum arundinaceum, S. spontaneum, Phragmites karka, Desmostachya bipinnata, Bothriochloa intermedia, Vitevaria zizanioides, Imperata cylindrica, Chrysopogon aciculatus, Panicum notatum. Themeda-Arundinella* grass cover, between 29° and 37°N, and between 73° and 81°E, and between 22° and 28.5°N, and 88° and 97°E possesses grass vegetation with representation of *Arundinella benghalensis*, *A.* nepaolensis, *Bothriochloa intermedia*, *Chrysopogon fulvus, Cymbopogon jwarancusa, Cynodon dactylon, Heteropogon contortus, Themeda anathera, Euloliopsis binata, Ischaemum barbatum, Apluda mutica, Arundinella khaseana, Pennisetum flaccidum*, *Chloris, Desmostachya. The* temperate alpine *grass cover,* between 29° and 37°N, and between 73° and 81°E, has wide diversity of species such as *Agropyron conaliculatum, Chrysopogon gryllus, Dactylis glomerata, Danthonia cachemyriana, Phleum alpinum, Carex nubigena, Poa pratensis, Stipa concinna. Poa alpina, Festuca lucida, Eragrostis nigra, Bromus ramosus*.

Genetic Resource Conservation

Across the globe there is large number of long term and midterm storage facilities of germplasm of various crops in addition to huge number with active germplasm centres for regular use by breeders. Biodiversity informatics plays a central enabling role in the research community's efforts to address scientific conservation and sustainability issues. Great strides have been made in the past decade establishing a framework for sharing data. The database has pivot around species name. However, to address the urgent questions around conservation, land-use, environmental change, sustainability, food security and ecosystem services that are facing Governments worldwide, need to understand how the ecosystem works. Hence, there is need of a system approach to understanding biodiversity that moves significantly beyond taxonomy and species observations (Hardisty, 2013).

In addition to forage value, the grassland species have wide diversity and economic value. Grasses have been on this earth as monocotyledonous plants and have been a survivor on the planet despite of various ecological changes. Many grasses hold the medicinal value and are a repository of some unique medicinal properties. It is very essential for humans to identify such important grasses and develop a strategy for their conservation (Dashora and Gosavi, 2013).

Conservation of Forage Genetic Resources

The systematic work on the collection, evaluation, documentation and conservation of germplasm of forage species, including wild and seedy taxa has been paid serious attention in the last few decades. In a concerted efforts by National Bureau of Plant Genetic Resources, germplasm of selected species were collected by ICAR Institutes State Departments of Agriculture/ Agricultural colleges of the State Agricultural Universities in the states. Most of them were evaluated for morphological traits. However, for forage crops we need to adopt modern rapid and automated chemical analyses regarding *in vitro* digestibility and nutritive value.

Duplication in the collected germplasm is a serious issue because it is increasing the volume. Through morphological evaluation it appears difficult to strike out the duplicates because of high environmental interaction. Hence, molecular tools need to be employed.

In such an effort, Chandra *et al*. (2006) studied the random amplified polymorphic DNA polymorphism in *Dichanthium* and identified genotype-specific markers. Similarly Cresswell *et al*. (2001) used amplified fragment length polymorphism markers to assess genetic diversity of *Lolium* species from Portugal and reported genetic variation within and between populations from the extremes of latitude and altitude.

Indian Grassland and Fodder Research Institute, Jhansi has good collection of diversity of these forage crops. The institute is maintaining >8500 germplasm of many fodder crops and range species collected through explorations and exchange. Proper documentation, indexing and deposition of reference seeds in National Gene Bank, NBPGR are some of the steps taken to stop misuse of our forage genetic resources.

The increasing demand for biomass leads to increasing pressure on land which can result in land-use changes, such as conversion from grassland to crop land. Recent findings from marginal grasslands show that increasing pressure on them can negatively influence ecosystem functioning, potentially compromising long-term production potentials. On the other hand, grassland communities in Europe suffer from mismanagement or under-management. In Europe many grasslands are no longer harvested however, the maintenance of different grassland species requires cutting (Hilger *et al*., 2015)

Forage Germplasm Introduction in India

During the last few decades introduction of new species, ecotypes, biotypes, wild relatives and improved cultivars have considerably enriched the genetic diversity available in India. Some of the important species introduced in recent past are Berseem (*Trifolium alexandrinum*), Oats (*Avena sativa*), Lucerne (*Medicago sativa*), Stylos (*Stylosanthes* sp.), Subabul (*Leucaena leucocepahala*), *Stylosanthes* spp, *Cenchrus* spp *etc*. However, much needs to be done as far as the introductions are concerned.

Participatory Biodiveristy Conservation

There are two main approaches to conserve plant genetic resources i.e. *In-situ* - conservation which is the protection of biological resources in their native environments and *Ex-situ* conservation, particularly where *in-situ* conservation cannot be practiced or will not be sufficient to ensure adequate protection for genetic.

In the era of intellectual property rights, human race has become commerce minded. For everything in kind or intellect, we need to pay. However, there are international platform which protect human welfare rights jointly with IPR. Byerlee and Fischer (2002) emphasized that partnerships are particularly relevant in PGR activities where the technical requirements include access to cutting-edge research tools, intellectual property, advanced scientific expertise, expensive and sophisticated equipment and solid infrastructure. Public Private Partnerships have become order of the day in several CGIAR centres to address specific areas which included apomixis in maize (CIMMYT-PHI, Syngenta, Limagrain), and grasses are the main source for apomixis gene.

India has traditionally been rich in forage and fodder resources. Since ancient times, Indians have practiced mixed farming where livestock formed an integral part of agriculture. Rich genetic diversity of both cultivated and rangeland species including trees, browse species, shrubs and herbaceous grasses and legumes. For thousands of years farmers have been domesticating plant species thereby developing a wide range of crop varieties adapted to specific needs and environmental conditions. An excellent example of protecting farmer's right over their natural resource in terms of landraces is provided in Indian Plant Variety Protection and Farmer's Right Act. This was done with the concept that informal community gene bank, i.e. farmer's maintaining biodiversity, exist at the village level, but these need to be formalized.

Traditionally farmers use diverse crops, trees and wild plant species, livestock and aquatic species to sustain/enhance their livelihood. The use of diverse species and varieties enhances their adaptability and resilience capacity to changing environmental and economic conditions. Genetic diversity is a key element in farmers livelihood strategies particularly in areas under high ecological, climatic and economic stresses and risks (Sthapit, *et al*.,2009)

Manu (2015) reports that Potshangbam Devakanta from Manipur shows the way in conserving the biodiversity of the state by farming around 100 traditional varieties of paddy and rare medicinal plants. This is smart and eco-friendly methods of farming to ensure his harvest is satisfactory year after year. He showed passion to conserve a wide variety of rice in his organic farm, including a black rice variety with medicinal properties, and other drought-resistant varieties rich in antioxidants. Devakanta, who won the PPVFRA (Protection of Plant Varieties And Farmers Rights Act) conservation award in 2012, also cultivates five varieties of the rare and highly nutritious variety of black rice, called 'chakhao poireiton'.

As a private partner, OSEVA PRO, Ltd. Grassland Research Station Rožnov – Zubøí took the lead and brought the first documented work on grass genetic resources linked to the establishment and development of the Grassland Research Station (GRS) in Rožnov pod Radhoštìm in 1920. Since 2003, the GRS Zubøí has become a participant to the National Programme with the responsibility for the collections of grasses and grass-like species. The collection consists now of 2357 accessions. Long-term preservation of seed grass is provided by the Genebank of the CRI in Prague (Dottlacil *et al*., 2013).

The Banni grasslands in the great and the little *ranns* of *Kachchh* in India were the old arms of the sea in the old geological period. Due to the eruption and formation of the Allah Bund near the Kori Creek, the lands in the Great and Little ranns got blocked up and were filled up by the deposits brought down by the Indus river. This is a place of naturally conserved grasses/legumes and shrubs. Vegetation of these grasslands comprises of, *Dichanthium-annulatum, Sporobolus helvolus, Chloris barbate, Cenchrus biflorus, Eleusine bianata, Elysecarpus rugosus, Heylandis latebrosa , Digitarea sanguinalis, Var Ciliaris, Crotolaria medicaginea, Indigofera spp. Sida spp. Malanocenchrus jacquemontii, Sporobolus diander, Cenchrus setigerus, Aristida adscensionis, Aristida funiculata, Setaria rhachitricho, Eragrostis minor and major, Eragrostis trimula, Cyprus rotundus, Desmostachya bipinnata, Cyperus rotundus, Cressa cretica, Eragrostis bulbosa , Kochia spp. Suaeda fruticosa*

The Peninsular India forms the important genetic resource centre for many grass crops which includes cereals, millets, sugarcane, lemon grass, ginger grass etc. About 50 wild relatives of relevant grass crops in Southern western Ghat region are documented from here (Raj and Sivadasan, 2006). The grasses *like Arundo donax* L., *Cynodon dactylon* Pers., *Desmostachya bipinnata* (L.) Stapf, *Heteropogon contortus* L., *Chrysopogon zizanioides* (L.) *Roberty, C. aciculatus* (Retz.) *Trin., Saccharum spontaneum* L., etc. are widely used as traditional medicines in Western Ghats region. There are 7 species belonging to 2 genera (*Chrysopogon* Trin. & *Cymbopogon* Spreng.) from which aromatic grass oils – Vetiver oil, Palmerosa oil, Citronella oil, Lemon grass oil, Ginger grass oil – are extracted and used (Raj and Sivadasan, 2007a). Dry grassland biomes of peninsular India are prime habitat for several endangered species. The patchy distribution of grasslands in the hot and semi-arid states of India requires urgent, but systematic planning and management as they are diminishing at an unprecedented rate. Conservation of dry grasslands is a global challenge (Vanak, 2013).

Similarly in Kerala State, the land of backwaters, is endowed with rich plant diversity. The wetland ecosystems of the state are usually located in the low altitude regions that comprise a high species diversity and endemism among grasses. Out of the approximately 400 grass species recorded from Kerala, about 230 species belonging to 22 genera are inhabited in both uplands and wetland areas. Among those, about 140 species are exclusively found in wetlands. The genera such as Aeluropus, Echinochloa, Elytrophorus, Hygroryza, Hymenachne, Leersia, Leptochloa, Phragmitis, Pseudoraphis, Sacciolepis, Acroceras, Spinifex, etc.are found only in wetland or coastal region in the State (Raj and Sivadasan, 2007b).

Another example of participatory Grassland Biodiversity Conservation is *Samvedana*. Phasepardhis, one of the wandering tribes of the Maharashtra region, have traditionally engaged in hunting as a means of livelihood. Samvedana, an organization comprising Phasepardhi and Chitrakathi tribals, is working to help tribals earn a living in new ways. Seeing people in Masa and Vadhavi move on their own into animal husbandry and nomadic trading, Kaustubh, working with Samvedana, is helping to replicate such models of alternate employment. The initiatives by Samvedana include preparing a Peoples Biodiversity Register of the grassland species in Akola and Washim, campaigning to create awareness on sustainable use and conservation of grasslands, and experimenting *in-situ* conservation efforts for the lesser florican.

The Plant Genome Savior Community Award instituted by Protection of Plant Varieties and Farmer's Rights Act (PPV & FRA), Ministry of Agriculture, Government of India, was awarded to a Seed Saver Farmers' Group of Jawhar tribal block in Thane district of Maharashtra, Indian in 2013 for the efforts of small and marginal farmers and communities in conservation, improvement and preservation of genetic resources of economic plants and their wild relatives in areas identified as agro biodiversity hotspots in the country. The community-led Crop Germplasm Conservation Programme for conservation, revival and sustainable use of crop genetic resources through people's participation was initiated by BAIF Development Research Foundation through its Associate Organization, Maharashtra Institute for Technology Transfer in Rural Areas (MITTRA), in Jawhar, tribal block of Thane district and Dhadgaon tribal block in Nandurbar district of Maharashtra in 2007. The main crops cultivated were Paddy, Finger millet, Common millet, Pigeon pea and Black gram.**The terrain – Thane district**

The tribal families in this cluster have traditionally cultivated over 300 diverse varieties of rice with specific attributes such as hunger satiation, instant energy provision during peak workloads and for medicinal use. This wonderful diversity of rice has formed the basis of a nutritious and secure diet for the tribal population. Dhadgaon block of Nandurbar district has an amazing diversity of Maize, Sorghum, Finger millet and other food and plants. It has conserved 170 landraces of paddy, 27 landraces of finger millet and 10 landraces of Proso millet in addition to 72 wild food resources documented. Two innovative farmers, Mavanji Pawar from Chowk village and Sunil Kamadi from Kamadipada in Jawhar block, were also selected for Plant Genome Savior Farmer Recognition 2011-12 for their valuable contribution in conservation of crop genetic resources.

The traditional farming systems have a key role in *in situ* conservation of plant diversity. The traditional farming systems were developed by farmers over years of experience to suit specific ecological conditions with a view to attaining stability and diversification in production (Singh and Misri 1995). The objectives of adopting mixed cropping were to reduce the risk of total crop failure due to uncertainty of monsoons and to have a variety of products, etc. As in Ladakh depending upon the local conditions, double or mixed cropping system is practiced (Dhar *et al.,* 1994). Seeds of local cultivars of pea are always grown as a mixed crop in Ladakh. Amongst pseudocereals, buckwheat (*Fagopyrum* spp.) is cultivated as a regular mixed crop and utilized as food, fodder, etc.

Thus, "Community based conservation" and "peoples' participation" have become part of the conventional rhetoric and more attention is being paid by international and national conservation organisations. There are now several examples of projects which involve local communities and seek to use economic incentives for the conservation and sustainable use of wildlife, protected areas, forests, wetlands, grasslands and other biodiversity rich areas. However, the practice of community based conservation remains problematic because of its high dependence on centralized bureaucratic organizations for planning and implementation (Pimbert and Pretty, 1997). Community based conservation is likely to be more cost effective and sustainable when national regulatory frameworks are left flexible enough to accommodate local peculiarities.

A number of national and international policy processes are underway to allow for the development of *sui generis* systems to protect local natural and genetic resources and related knowledge about their management, use and maintenance. Despite agreements reached on paper at international and national levels, such as the Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits derived from their use, and the International Treaty on Plant Genetic Resources for Food and Agriculture, progress in implementation has been slow and in many countries, painful. Promising examples from the field could stimulate policy debates and inspire implementation processes (Vernooy and Ruiz, 2013)

Breeding material

A lot of segregating material is being generated across the word through intervarietal crossing, interspecific crossing, wide hybridization and mutation. However, breeders after selecting the plant types with desirable traits expressed in the given environment are being selected and rest discarded. If this wealth is made available for evaluation in different environment, it can enrich germplasm resource and enhance breeding pace. Some of the novel germplasm in forage species developed in India and conserved at NBPGR are listed here under:

Climate change and genetic resource

The grasses or other species in grasslands are growing in highly diverse and harsh condition. These are harbouring genes for tolerance to many abiotic stresses such as light, heat and salinity/alkalinity. Hence, this wide variability, if conserved suitably can prove to be resource to address climate change issue. Many studies and reports discuss the importance of plant genetic resources for crop production in view of climate change and their key role in adapting to adverse climatic conditions and, hence, for food security. Important is that underutilized or minor crops often harbour high levels of genetic diversity being maintained on-farm in small-scale farming systems; however they are relatively neglected by formal research and development strategies, including breeding programs (Galluzzi *et al*., 2014).

In the debate on climate change and agriculture, the role of *in situ* conservation and on-farm management of agricultural biodiversity is seldom discussed with the attention it deserves. It is important to consider whether climate change will affect on-farm management of cultivated landraces and their wild relatives. Jarvis *et al*.(2008ab) used current and projected future climate data for ~2055, and a climate envelope species distribution model to predict the impact of climate change on the wild relatives of groundnut (*Arachis hypogea*), potato (*Solanum tuberosum*) and cowpea (*Vigna unguiculata*). They reported that wild groundnuts to be the most affected group and cowpea to be the least affected

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